DOCUMENT RESUME

ED 158 124 CE 017 774

TITLE Engineering and Related Occupations. Reprinted from the Occupational Outlook Handbook, 1978-79 Edition.
INSTITUTION Bureau of Labor Statistics (DOL), Washington, D.C.
REPORT NO Bull-1955-20
PUB DATE 78
NOTE 25p.; Photographs in this document will not reproduce well; For related documents see CE 017 756-797
AVAILABLE FROM Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 ($0.50 per reprint; $8.00 for set of 42)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Aerospace Industry; Agricultural Engineering; Broadcast Industry; Ceramics; Civil Engineering; Drafting; Electrical Occupations; *Employment Opportunities; *Employment Projections; *Employment Qualifications; Employment Trends; *Engineering Technicians; *Engineers; Human Engineering; Industrial Technology; Information Sources; Job Skills; Job Training; Mechanical Design Technicians; Metallurgy; *Occupational Information; Occupational Mobility; Ocean Engineering; Petroleum Industry; Promotion (Occupational); Salaries; Wages; Work Environment

ABSTRACT

Focusing on engineering and related occupations, this document is one in a series of forty-one reprints from the Occupational Outlook Handbook providing current information and employment projections for individual occupations and industries through 1985. The specific occupations covered in this document include aerospace engineers, agricultural engineers, biomedical engineers, ceramic engineers, chemical engineers, civil engineers, electrical engineers, industrial engineers, mechanical engineers, metallurgical engineers, mining engineers, petroleum engineers, broadcast technicians, drafters, engineering and science technicians, and surveyors. The following information is presented for each occupation or occupational area: a code number referenced to the Dictionary of Occupational Titles; a description of the nature of the work; places of employment; training, other qualifications, and advancement; employment outlook; earnings and working conditions; and sources of additional information. In addition to the forty-one reprints covering individual occupations or occupational areas (CE 017 757-797), a companion document (CE 017 756) presents employment projections for the total labor market and discusses the relationship between job prospects and education. (BM)

ED158

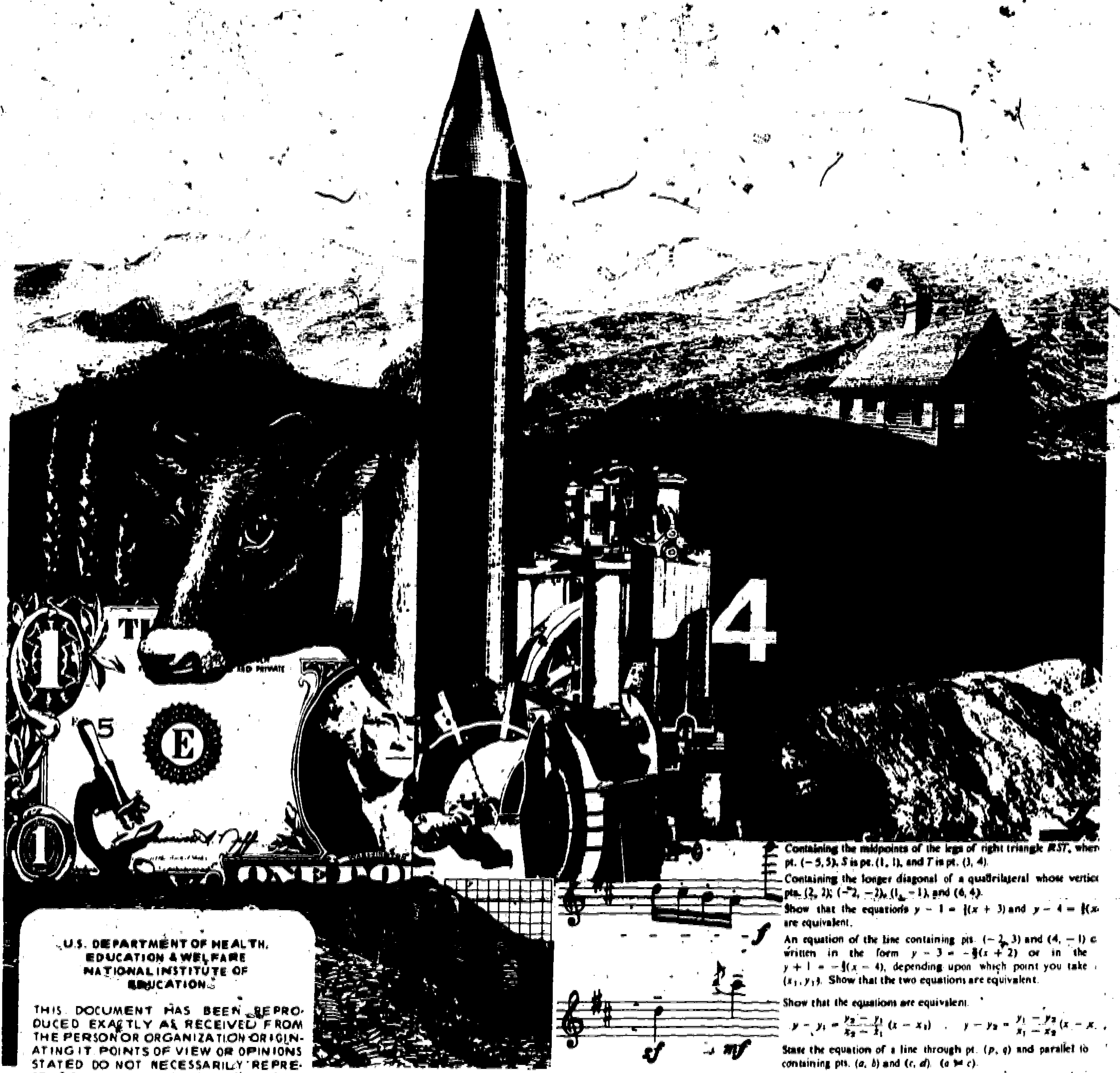
Engineering and Related Occupations

CE

Reprinted from the Occupational Outlook Handbook, 1978-79 Edition.

U.S. Department of Labor
Bureau of Labor Statistics
1978

Bulletin 1955-20



CE 017 774

ENGINEERS

The work of engineers affects our lives in thousands of different ways. Their past accomplishments have enabled us to drive safer automobiles, reach the moon, and even prolong life through special machinery. Future accomplishments could help us increase energy supplies, develop more pollution-free powerplants, and aid medical science's fight against disease.

In 1976, more than 1.1 million persons were employed as engineers, the second largest professional occupation, exceeded only by teachers. Most engineers specialize in one of the more than 25 specialties recognized by professional societies. Within the major branches are over 85 minor subdivisions. Structural, environmental, hydraulic, and highway engineering, for example, are subdivisions of civil engineering. Engineers also may specialize in the engineering problems of one industry, such as motor vehicles, or in a particular field of technology, such as propulsion or guidance systems. This section, which contains an overall discussion of engineering, is followed by separate statements on 12 branches of the profession—aerospace, agricultural, biomedical, ceramic, chemical, civil, electrical, industrial, mechanical, metallurgical, mining, and petroleum engineering.

Nature of the Work

Engineers apply the theories and principles of science and mathematics to practical technical problems. Often their work is the link between a scientific discovery and its useful application. Engineers design machinery, products, systems, and processes for efficient and economical performance. They develop electric power, water supply, and waste disposal systems to meet the problems of urban living. They design industrial machinery and equipment used to manufacture goods; and heating, air-conditioning, and ventilation equipment for more comfortable living. Engineers also develop scientific equipment to probe outer space and the ocean depths, design defense and weapons systems for the Armed Forces, and design, plan, and supervise the construction of buildings, highways, and rapid transit systems. They design and develop consumer products such as automobiles, television sets, and refrigerators, and systems for control and automation of manufacturing, business, and management processes.

Engineers must consider many factors in developing a new product. For example, in developing new devices to reduce automobile exhaust emissions, engineers must determine the general way the device will work, design and test all components, and fit them together in an integrated plan. They must then evaluate the overall effectiveness of the new device, as well as its cost and reliability. These factors apply to most products, including those as different as medical equipment, electronic computers, and industrial machinery.

In addition to design and development, many engineers work in testing, production, operation, or maintenance. They supervise the operation of production processes, determine the causes of breakdowns, and perform tests on newly manufactured products to ensure that quality standards are maintained. They also estimate the time needed to complete engineering projects and their cost. Still others are in administrative and management jobs where an engineering background is necessary, or in sales where they discuss the technical aspects of a product and assist in planning its installation or use. (See statement on manufacturers' salesworkers elsewhere in the *Handbook*.) Engineers with considerable education or experience sometimes work as consultants. Some with advanced degrees teach in the engineering schools of colleges and universities.

Engineers within each of the branches may apply their specialized knowledge to many fields. Electrical engineers, for example, work in medicine, computers, missile guidance, or electric power distribution. Because engineering problems are usually complex, the work in some fields cuts across the traditional branches. Using a team approach to solve problems, engineers in one field often work closely with specialists in other scientific, engineering, and business occupations.

Places of Employment

More than half of all engineers work in manufacturing industries—mostly in the electrical and electronic equipment, aircraft and parts, machinery, chemicals, scientific instruments, primary metals, fabricated metal products, and motor vehicle industries. Over 340,000 were employed in nonmanufacturing industries in 1976, primarily in construction, public utilities, engineering and architectural services, and business and management consulting services.

Federal, State, and local governments employed about 150,000 engineers. Over half of these worked for the Federal Government, mainly in the Departments of Defense, Interior, Agriculture, Transportation, and in the National Aeronautics and Space Administration. Most engineers in State and local government agencies worked in highway and public works departments.

Colleges and universities employed about 45,000 engineers in research and teaching jobs, and a small number worked for nonprofit research organizations.

Engineers are employed in every State, in small and large cities and in rural areas. Some branches of engineering are concentrated in particular industries and geographic areas, as discussed in the statements later in this chapter.

Training, Other Qualifications, and Advancement

A bachelor's degree in engineering is the generally accepted educational requirement for beginning engineering jobs. College graduates trained in one of the natural sciences or mathematics also may qualify for some beginning jobs. Experienced technicians with some engineering education are occasionally able to

advance to some types of engineering jobs.

Many colleges recently have established 2- or 4-year programs leading to degrees in engineering technology. These programs prepare students for practical design and production work rather than for jobs that require more theoretical scientific and mathematical knowledge. Graduates of 4-year engineering technology programs may get jobs similar to those obtained by engineering bachelor's degree graduates. However, the status of those with the engineering technology degree is still not clear. Some employers regard them as having skills somewhere between those of a technician and an engineer.

Graduate training is being emphasized for an increasing number of jobs; it is essential for most beginning teaching and research positions, and is desirable for advancement. Some specialties, such as nuclear engineering, are taught mainly at the graduate level.

About 250 colleges and universities offer a bachelor's degree in engineering, and over 50 colleges offer a bachelor's degree in engineering technology. Although programs in the larger branches of engineering are offered in most of these institutions, some small specialties are taught in only a very few. Therefore, students desiring specialized training should investigate curriculums before selecting a college. Admissions requirements for undergraduate engineering schools usually include high school courses in advanced mathematics and the physical sciences.

In a typical 4-year curriculum, the first 2 years are spent studying basic sciences—mathematics, physics, chemistry, introductory engineering—and the humanities, social sciences, and English. The last 2 years are devoted, for the most part, to specialized engineering courses. Some programs offer a general engineering curriculum, permitting the student to choose a specialty in graduate school or acquire it on the job.

Some engineering curriculums require more than 4 years to complete. A number of colleges and universities now offer 5-year master's degree programs. In addition, several engineering schools have formal arrangements with liberal arts colleges whereby a student spends 3 years in a liberal arts college studying pre-engineering subjects and 2 years in an engineering school and receives a bachelor's degree from each.

Some schools have 5- or even 6-year cooperative plans where students coordinate classroom study and practical work experience. In addition to gaining useful experience, students can finance part of their education. Because of the need to keep up with rapid advances in technology, engineers often continue their education throughout their careers.

All 50 States and the District of Columbia require licensing for engineers whose work may affect life, health, or property, or who offer their services to the public. In 1976, there were over 300,000 registered engineers. Generally, registration requirements include a degree from an accredited engineering school, 4 years of relevant work experience, and the passing of a State examination.

Engineering graduates usually begin work under the supervision of experienced engineers. Some companies have special programs to acquaint new engineers with special industrial practices and to determine the specialties for which they are best suited. Experienced engineers may advance to positions of greater responsibility and some engineers move to management or administrative positions after several years of engineering. Some engineers obtain graduate degrees in business administration to improve their advancement opportunities, while still others obtain law degrees and become patent attorneys. Many high level executives in private industry who began their careers as engineers.

Engineers should be able to work as part of a team and should have creativity, an analytical mind, and a capacity for detail. They should be able to express their ideas well orally and in writing.

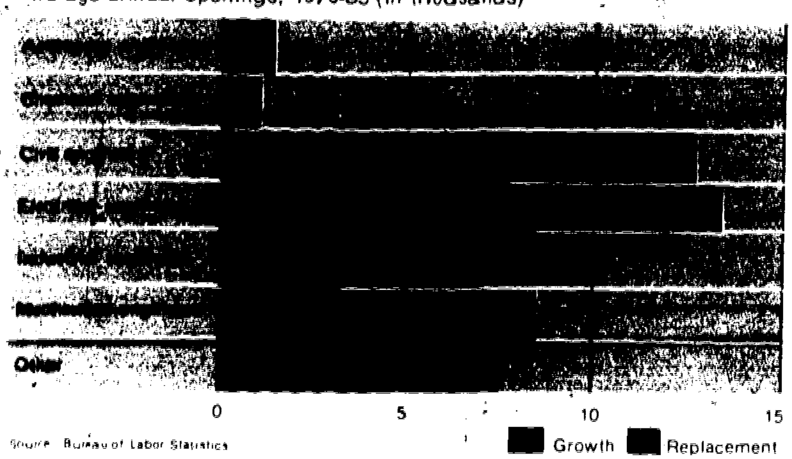
Employment Outlook

Employment opportunities for engineers are expected to be good through the mid-1980's in most specialities. In addition there may be some opportunities for college graduates from related fields in certain engineering jobs.

Employment requirements for engineers are expected to grow slightly faster than the average for all occupations through the mid-1980's.

Growth and replacement needs are expected to provide many job openings for engineers

Selected engineering occupations
Average annual openings, 1976-85 (in thousands)



Much of this growth will stem from industrial expansion to meet the demand for more goods and services. More engineers will be needed in the design and construction of factories, utility systems, office buildings, and transportation systems, as well as in the development and manufacture of defense-related products, scientific instruments, industrial machinery, chemical products, and motor vehicles.

Engineers will be required in energy-related activities developing sources of energy as well as designing energy-saving systems for automobiles, homes, and other buildings. Engineers also will be needed to solve environmental problems.

The level of expenditures in some of these areas, particularly defense, however, has fluctuated in the past, affecting the requirements for engineers, and may do so in the future. The outlook for engineers given here is based on the assumption that defense spending will increase from its 1976 level but will still be lower than the peak levels of the 1960's. If, however, defense activity is higher or lower than the level assumed, the demand for engineers will be higher or lower than now expected. Further, if the demand for their specialty declines, engineers may lose their jobs. This can be a particular problem for older engineers, who may face difficulties in finding other engineering jobs. These difficulties can be minimized by selection of a career in one of the more stable industries and engineering specialties, and by continuing education to keep up on the latest technological developments.

Despite these problems, over the long run the number of people seeking jobs as engineers is expected to be in balance with the number of job openings.

(The outlook for various branches is discussed in the separate statements later in this section.)

Earnings and Working Conditions

According to the College Placement Council, engineering graduates with a bachelor's degree and no experience were offered average starting salaries of $14,800 a year in private industry in 1976; those with a master's degree and no experience, almost $16,500 a year; and those with a Ph. D., over $21,000. Starting offers for those with the bachelor's degree vary by branch as shown in the accompanying table.

Starting salaries for engineers, by branch, 1976

Branch	*Average starting salaries*
Aeronautical engineering	$14,268
Chemical engineering	16,212
Civil engineering	13,764
Electrical engineering	14,448
Industrial engineering	14,568
Mechanical engineering	14,964
Metallurgical engineering	15,600

In the Federal Government in 1977, engineers with a bachelor's degree and no experience could start at $9,303 or $11,523 a year, depending on their college records. Those with a master's degree could start at $11,523 or $14,097. Those having a Ph. D. degree could begin at $17,056 or $20,442. The average salary for experienced engineers in the Federal Government was about $25,900 in 1977.

For a 9-month academic college year in 1976, faculty members with 5 years' experience beyond the bachelor's degree received about $15,150; those with 18 to 20 years experience beyond the bachelor's degree received about $21,150. (See statement on college and university teachers elsewhere in the *Handbook*.)

Engineers can expect an increase in earnings as they gain experience. According to an Engineering Manpower Commission survey, the average salary for engineers with 20 years of experience was $26,000 in 1976. Some in management positions had much higher earnings.

Many engineers work indoors in offices and research laboratories. Others, however, spend time in more active work—in a factory or mine, at a construction site, or some other outdoor location.

Sources of Additional Information

General information on engineering careers—including engineering school requirements, courses of study, and salaries—is available from:

Engineers' Council for Professional Development, 345 E. 47th St., New York, N.Y. 10017.

Engineering Manpower Commission of Engineers Joint Council, 345 E. 47th St., New York, N.Y. 10017.

National Society of Professional Engineers, 2029 K St. NW., Washington, D.C. 20006.

For information about graduate study, contact:

American Society for Engineering Education, One Dupont Circle, Suite 400, Washington, D.C. 20036.

Societies representing the individual branches of the engineering profession are listed later in this chapter. Each can provide information about careers in the particular branch. Many other engineering organizations are listed in the following publications available in most libraries or from the publisher:

Directory of Engineering Societies, published by Engineers Joint Council, 345 E. 47th St., New York, N.Y. 10017.

Scientific and Technical Societies of the United States and Canada, published by the National Academy of Sciences, National Research Council, 2101 Constitution Ave., NW., Washington, D.C. 20418.

Some engineers are members of labor unions. Information on engineering unions is available from:

International Federation of Professional and Technical Engineers, 1126 16th St. NW., Washington, D.C. 20036.

AEROSPACE ENGINEERS

(D.O.T. 002.081)

Nature of the Work

Aerospace engineers design, develop, test, and help produce commercial and military aircraft, missiles, and spacecraft. They play an important role in advancing the state of technology in commercial aviation, defense systems, and space exploration.

Aerospace engineers often specialize in an area of work like structural

Aerospace engineer checking out part of a spacecraft.

design, navigational guidance and control, instrumentation and communication, or production methods. They also may specialize in one type of aerospace product such as passenger planes, helicopters, satellites, or rockets.

Places of Employment

About 50,000 aerospace engineers were employed in 1976, mainly in the aircraft and parts industry. Some worked for Federal Government agencies, primarily the National Aeronautics and Space Administration and the Department of Defense. A few worked for commercial airlines, consulting firms, and colleges and universities.

Employment Outlook

Employment of aerospace engineers is expected to grow more slowly than the average for all occupations through the mid-1980's. Employment of aerospace engineers is largely determined by the level of Federal expenditures on defense and space programs: in the past, rapid changes in spending levels have usually been accompanied by sharp employment fluctuations. Expenditures for the space program are expected to increase only slightly from 1976 to the mid-1980's, while defense spending will probably increase moderately. Although few jobs will be created by employment growth, many workers will be required to fill openings created by deaths, retirements, and transfers of workers to other occupations. (See introductory section of this chapter for discussion of training requirements and earnings. See also statement on aircraft, missile, and spacecraft manufacturing elsewhere in the *Handbook*.)

Sources of Additional Information

American Institute of Aeronautics and Astronautics, Inc., 1290 Avenue of the Americas, New York, N.Y. 10019.

AGRICULTURAL ENGINEERS

(D.O.T. 013.081)

Nature of the Work

Agricultural engineers design machinery and equipment, and develop methods to improve efficiency in the production, processing, and distribution of food and other agricultural products. They also are concerned with the conservation and management of energy, soil, and water resources. Agricultural engineers work in research and development, production, sales, or management.

Places of Employment

Most of the 12,000 agricultural engineers employed in 1976 worked for manufacturers of farm equipment, electric utility companies, and distributors of farm equipment and supplies. Some worked for engineering consultants who supply services to farmers and farm-related industries; others were independent consultants.

About 450 agricultural engineers are employed in the Federal Government, mostly in the Department of Agriculture; some are employed in colleges and universitites; and a few work in State and local governments.

Employment Outlook

Employment of agricultural engineers is expected to grow faster than the average for all occupations through the mid-1980's. Increasing demand for agricultural products, modernization of farm operations, increasing emphasis on conservation of resources, and the use of agricultural products and wastes as industrial raw materials should provide additional opportunities for engineers. (See introductory part of this section

for information on training requirements and earnings. See also statement on agriculture elsewhere in the *Handbook*.)

Sources of Additional Information

American Society of Agricultural Engineers, 2950 Niles Rd., St. Joseph, Mich. 49085.

BIOMEDICAL ENGINEERS

Nature of the Work

Biomedical engineers use engineering principles to solve medical and health-related problems. Many do research, along with life scientists, chemists, and members of the medical profession, on the engineering aspects of the biological systems of man and animals. Some design and develop medical instruments and devices including artificial hearts and kidneys, lasers for surgery, and pacemakers that regulate the heartbeat. Other biomedical engineers adapt computers to medical science, and design and build systems to modernize laboratory, hospital, and clinical procedures. Most engineers in this field require a sound background in one of the major engineering disciplines (mechanical, electrical, industrial, or chemical) in addition to specialized biomedical training.

Places of Employment

There were about 3,000 biomedical engineers in 1976. Most teach and do research in colleges and universities. Some work for the Federal Government, primarily in the National Aeronautics and Space Administration, or in State agencies. An increasing number work in private industry developing new devices, techniques, and systems for improving health care. Some work in sales positions.

Employment Outlook

Employment of biomedical engineers is expected to grow faster than the average for all occupations through the mid-1980's, but the actual number of openings is not likely to be very large. Those who have advanced degrees will be in demand to teach and to fill jobs resulting from increased expenditures for medical research. Increased research funds could also create new positions in instrumentation and systems for the delivery of health services. (See introductory part of this chapter for information on training requirements and earnings.)

Many biomedical engineers are involved in research.

Sources of Additional Information

Alliance for Engineering in Medicine and Biology, Suite 404, 4405 East-West Highway, Bethesda, Md. 20014.

Biomedical Engineering Society, P.O. Box 2399, Culver City, Calif. 90230.

CERAMIC ENGINEERS

(D.O.T. 006.081)

Nature of the Work

Ceramic engineers develop new ceramic materials and methods for making ceramic materials into useful products. Although to some, the word ceramics means pottery, ceramics actually include all nonmetallic, inorganic materials which require the use of high temperature in their processing. Thus, ceramic engineers work on diverse products such as glassware, heat-resistant materials for furnaces, electronic components, and nuclear reactors. They also design and supervise the construction of plants and equipment to manufacture these products.

Ceramic engineers generally specialize in one product or more—for example, products of refractories (fire-and heat-resistant materials such as firebrick); whitewares (porcelain and china dinnerware or high voltage electrical insulators); structural materials (such as brick, tile and terra cotta); electronic ceramics (ferrites for memory systems and microwave devices); protective and refractory coatings for metals; glass; abrasives; cement technology; or fuel elements for atomic energy.

Places of Employment

About 12,000 ceramic engineers were employed in 1976, mostly in the stone, clay, and glass industry. Others work in industries that produce or use ceramic products such as the iron

Most ceramic engineers are employed in the stone, clay, and glass industry.

and steel, electrical equipment, aerospace, and chemicals industries. Some are in colleges and universities, independent research organizations, and the Federal Government.

Employment Outlook

Employment of ceramic engineers is expected to grow faster than the average for all occupations through the mid-1980's. Programs related to nuclear energy, electronics, defense, and medical science will provide job opportunities for ceramic engineers. Additional ceramic engineers will be required to improve and adapt traditional ceramic products, such as whitewares and abrasives, to new uses. The development of filters and catalytic surfaces to reduce pollution, and the development of ceramic materials for energy conversion and conservation, should create additional openings for ceramic engineers. (See introductory part of this section for information on training requirements and earnings.)

Sources of Additional Information

American Ceramic Society, 65 Ceramic Dr., Columbus, Ohio 43214.

CHEMICAL ENGINEERS

(D.O.T. 008.081)

Nature of the Work

Chemical engineers are involved in many phases of the production of chemicals and chemical products. They design equipment and chemical plants as well as determine methods of manufacturing the product. Often, they design and operate pilot plants to test their work and develop chemical processes such as those to remove chemical contaminants from waste materials. Because the duties of chemical engineers cut across many fields, these professionals must have a working knowledge of chemistry, physics, and mechanical and electrical engineering.

This branch of engineering is so diversified and complex that chemical engineers frequently specialize in a particular operation such as oxidation or polymerization. Others specialize in a particular area such as pollution control or in the production of a specific product like plastics or rubber.

Places of Employment

Most of the 50,000 chemical engineers working in 1976 were in manufacturing industries, primarily those producing chemicals, petroleum, and related products. Some worked in government agencies or taught and did research in colleges and universities. A small number worked for independent research institutes and engineering consulting firms, or as independent consulting engineers.

Employment Outlook

Employment of chemical engineers is expected to grow about as fast as the average for all occupations through the mid-1980's. A major factor underlying this growth is industry expansion—the chemicals industry in particular.

The growing complexity and automation of chemical processes will require additional chemical engineers to design, build, and maintain the necessary plants and equipment. Chemical engineers also will be needed to solve problems dealing with environmental protection, development of synthetic fuels, and the design and development of nuclear reactors. In addition, development of new chemicals used in the manufacture of consumer goods, such as plastics and synthetic fibers, probably will create additional openings. (See introductory part of this section for information on training requirements and earnings. See also the statement on chemists and the industrial chemical industry elsewhere in the *Handbook*.)

Sources of Additional Information

American Institute of Chemical Engineers, 345 East 47th St., New York, N.Y. 10017.

created by a growing population and an expanding economy. Work related to solving problems of environmental pollution and energy self-sufficiency will also require additional civil engineers.

Many civil engineers also will be needed each year to replace those who retire, die, or transfer to other occupations. (See introductory part of this section for information on training requirements and earnings.)

Sources of Additional Information

American Society of Civil Engineers, 345 E. 47th St., New York, N.Y. 10017.

Chemical engineer checks production instructions at chemical plant.

CIVIL ENGINEERS

(D.O.T. 005.081)

Nature of the Work

Civil engineers, who work in the oldest branch of the engineering profession, design and supervise the construction of roads, harbors, airports, tunnels, bridges, water supply and sewage systems, and buildings. Major specialties within civil engineering are structural, hydraulic, environmental (sanitary), transportation (including highways and railways), geotechnical, and soil mechanics.

Many civil engineers are in supervisory or administrative positions ranging from supervisor of a construction site to city engineer to top-level executive. Others teach in colleges and universities or work as consultants.

Places of Employment

About 155,000 civil engineers were employed in 1976. Most work for Federal, State, and local government agencies or in the construction industry. Many work for consulting engineering and architectural firms or as independent consulting engineers. Others work for public utilities, railroads, educational institutions, and manufacturing industries.

Civil engineers work in all parts of the country, usually in or near major industrial and commercial centers. They often work at construction sites, sometimes in remote areas or in foreign countries. In some jobs, they must often move from place to place to work on different projects.

Employment Outlook

Employment of civil engineers is expected to increase about as fast as the average for all occupations through the mid-1980's. Job opportunities will result from the growing needs for housing, industrial buildings, electric power generating plants, and transportation systems

ELECTRICAL ENGINEERS

(D.O.T. 003.081, .151, and .187)

Nature of the Work

Electrical engineers design, develop, test, and supervise the manufacture of electrical and electronic equipment. Electric equipment includes power generating and transmission equipment used by electric motors, machinery controls, and lighting and wiring in buildings, and in automobiles and aircraft. Electronic equipment includes radar, computers, communications equipment, missile guidance systems, and consumer goods such as televisions and stereos.

Electrical engineers generally specialize in a major area—such as integrated circuits, computers, electrical equipment manufacturing, communications, or power distributing equipment—or in a subdivision of these areas—microwave communication or aviation electronic systems, for example. Electrical engineers design new products and specify their uses and write performance requirements and maintenance schedules. They also test equipment, solve operating problems, and estimate the time and cost of engineering projects. Besides employment in research, development, and design, many are in manufacturing, administration and management, technical sales, or college teaching.

Most civil engineers work for construction companies and Federal, State, and local governments.

Places of Employment

Electrical engineering is the largest branch of the profession. About 300,000 electrical engineers were employed in 1976, mainly by manufacturers of electrical and electronic equipment, aircraft and parts, business machines, and professional and scientific equipment. Many work for telephone, telegraph, and electric light and power companies. Large numbers are employed by government agencies and by colleges and universities. Others work for construction firms, for engineering consultants, or as independent consulting engineers.

Employment Outlook

Employment of electrical engineers is expected to increase about as fast as average for all occupations through the mid-1980's. Although increased demand for computers, communications, and military electronics is expected to be the major contributor to this growth, demand for electrical and electronic consumer goods, along with increased research and development in new types of power generation, should create additional jobs. Many electrical engineers also will be needed to replace personnel who retire, die, or transfer to other fields of work.

The long-range outlook for electrical engineers is based on the assumption that defense spending in the mid-1980's will increase from the 1976 level, but will still be somewhat lower than the peak level of the late 1960's. If defense activity is higher or lower than the projected level, the demand for electrical engineers will be higher or lower than now expected.

(See introductory part of this section for information on training requirements and earnings. See also statement on electronics manufacturing elsewhere in the *Handbook*.)

Sources of Additional Information

Institute of Electrical and Electronic Engineers/United States Activities Board, 2029 K St., N.W., Washington, D.C. 20006.

Electrical engineer developing specialized electrical equipment.

INDUSTRIAL ENGINEERS

(D.O.T. 012.081, .168, and .188)

Nature of the Work

Industrial engineers determine the most effective ways for an organization to use the basic factors of production—people, machines, and materials. They are more concerned with people and methods of business organization than are engineers in other specialties who generally are concerned more with particular products or processes, such as metals, power, or mechanics.

To solve organizational, production, and related problems most efficiently, industrial engineers design data processing systems and apply mathematical concepts (operations research techniques). They also develop management control systems to aid in financial planning and cost analysis, design production planning and control systems to coordinate activities and control product quality, and design or improve systems for the physical distribution of goods and services. Industrial engineers also conduct plant location surveys, where they look for the best combination of sources of raw materials, transportation, and taxes, and develop wage and salary administration systems and job evaluation programs. Because the work is closely related, many industrial engineers move into management positions.

Industrial engineer reviewing film of production process to check for problems.

Places of Employment

About 200,000 industrial engineers were employed in 1976; more than two-thirds worked in manufacturing industries. Because their skills can be used in almost any type of company, they are more widely distributed among industries than are those in other branches of engineering. For example, some work for insurance companies, banks, construction and mining firms, and public utilities. Hospitals, retail organizations, and other large business firms employ industrial engineers to improve operating efficiency. Still others work for government agencies and colleges and universities. A few are independent consulting engineers.

Employment Outlook

Employment of industrial engineers is expected to grow faster than the average for all occupations through the mid-1980's. The increasing complexity of industrial opera-

tions and the expansion of automated processes, along with industry growth, are factors contributing to employment growth. Increased recognition of the importance of scientific management and safety engineering in reducing costs and increasing productivity, and the need to solve environmental problems, should create additional opportunities.

Additional numbers of industrial engineers will be required each year to replace those who retire, die, or transfer to other occupations. (See introductory part of this section for information on training requirements and earnings.)

Sources of Additional Information

American Institute of Industrial Engineers, Inc., 25 Technology Park/Atlanta, Norcross, Ga. 30092.

MECHANICAL ENGINEERS

(D.O.T. 007.081, .151, .168, and .187)

Nature of the Work

Mechanical engineers are concerned with the production, transmission, and use of power. They design and develop power-producing machines such as internal combustion engines, steam and gas turbines, and jet and rocket engines. They also design and develop power-using machines such as refrigeration and air-conditioning equipment, elevators, machine tools, printing presses, and steel rolling mills.

The work of mechanical engineers varies by industry and function since many specialties have developed within the field. Specialties included are motor vehicles, marine equipment, energy conversion systems, heating, ventilating and air-conditioning, instrumentation, and machines for specialized industries, such as petroleum, rubber and plastics, and construction.

Large numbers of mechanical engineers do research, test, and design work. Many are administrators or managers, while others work in maintenance, technical sales, and production operations. Some teach in colleges and universities or work as consultants.

Places of Employment

About 200,000 mechanical engineers were employed in 1976. Almost three-fourths were employed in manufacturing—mainly in the primary and fabricated metals, machinery, transportation equipment, and electrical equipment industries. Others worked for government agencies, educational institutions, and consulting engineering firms.

Employment Outlook

Employment of mechanical engineers is expected to increase about as fast as the average for all occupations through the mid-1980's. The growing demand for industrial machinery and machine tools and the increasing complexity of industrial machinery and processes will be major factors supporting increased employment opportunities. Mechanical engineers will be needed to develop new energy systems and to help solve environmental pollution problems.

Large numbers of mechanical engineers also will be required each year to replace those who retire, die, or transfer to other occupations. (See introductory part of this section for information on training requirements and earnings. See also statement on occupations in the atomic energy field elsewhere in the *Handbook*.)

Sources of Additional Information

The American Society of Mechanical Engineers, 345 E. 47th St., New York, N.Y. 10017.

METALLURGICAL ENGINEERS

(D.O.T. 011.081)

Nature of the Work

Metallurgical engineers develop methods to process and convert metals into useful products. Most of these engineers generally work in one of the three main branches of metallurgy—extractive or chemical, physical, and mechanical. Extractive metallurgists are concerned with extracting metals from ores, and refining and alloying them to obtain useful metal. Physical metallurgists deal with the nature, structure, and physical properties of metals and their alloys, and with methods of converting refined metals into final products. Mechanical metallurgists develop methods to work and shape metals such as casting, forging, rolling, and drawing. Scientists working in this field are known as metallurgists or materials scientists, but the distinction between scientists and engineers in this field is small.

Places of Employment

The metalworking industries—primarily the iron and steel and nonferrous metals industries—employed over one-half of the estimated 17,000 metallurgical and materials engineers in 1976. Metallurgical engineers also work in industries that manufacture machinery, electrical equipment, and aircraft and parts, and in the mining industry. Some work for government agencies and colleges and universities.

Employment Outlook

Employment of metallurgical and materials engineers is expected to grow faster than the average for all occupations through the mid-1980's. An increasing number of these engineers will be needed by the metalworking industries to develop new metals and alloys as well as to adapt current ones to new needs. For ex-

Metallurgical engineers study the physical properties of metal.

ample, communications equipment, computers, and spacecraft require lightweight metals of high purity. As the supply of high-grade ores diminishes, more metallurgical engineers will be required to develop new ways of recycling solid waste materials in addition to processing low-grade ores now regarded as unprofitable to mine. Metallurgical engineers also will be needed to solve problems associated with the efficient use of nuclear energy. (See introductory part of this section for information on training requirements and earnings. Also see statement on the iron and steel industry elsewhere in the *Handbook*.)

Sources of Additional Information

The Metallurgical Society of the Am... Institute of Mining, Metallurgical, and Petroleum Engineers, 345 E. 47th St., New York, N.Y. 10017.

American Society for Metals, Metals Park, Ohio 44073.

MINING ENGINEERS

(D.O.T. 010.081 and .187)

Nature of the Work

Mining engineers find, extract, and prepare minerals for manufacturing industries to use. They design the layouts of open pit and underground mines, supervise the construction of mine shafts and tunnels in underground operations, and devise methods for transporting minerals to processing plants. Mining engineers are responsible for the economic and efficient operation of mines and mine safety, including ventilation, water supply, power, communications, and equipment maintenance. Some mining engineers work with geologists and metallurgical engineers to locate and appraise new ore deposits. Others develop new mining equipment or direct mineral processing operations, which involve separating minerals from the dirt, rocks, and other materials they are mixed with. Mining engineers frequently specialize in the mining of one specific mineral such as coal or copper.

With increased emphasis on protecting the environment, many mining engineers have been working to solve problems related to mined-land reclamation and water and air pollution.

Places of Employment

About 6,000 mining engineers were employed in 1976. Most work in the mining industry. Some work for firms that produce equipment for the mining industry, while others work in colleges and universities, in government agencies, or as independent consultants.

Mining engineers are usually employed at the location of mineral deposits, often near small communities. However, those in research, teaching, management, consulting, or sales often are located in large metropolitan areas.

Employment Outlook

Employment of mining engineers is expected to increase faster than the average for all occupations through the mid-1980's. Efforts to attain energy self-sufficiency should spur the demand for coal, and therefore for mining engineers in the coal industry. The increase in demand for coal will depend, to a great extent, on the availability and price of other domestic energy sources such as petroleum, natural gas, and nuclear energy. More technologically advanced mining systems and further enforcement of mine health and safety regulations also will increase the need for mining engineers. In addition, exploration for all other minerals is also increasing. Easily mined deposits are being depleted, creating a need for engineers to devise more efficient methods for mining low-grade ores. Employment opportunities also will arise as new alloys and new uses for metals increase the demand for less widely used ores. Recovery of metals from the sea and the development of oil shale deposits could present major challenges to the mining engineer. (See introductory part of this section for information on training requirements and earnings. See also statement on mining elsewhere in the *Handbook*.)

Mining engineers are responsible for the efficient operation of mines and mine safety

Sources of Additional Information

[illegible]

Places of Employment

About 20,000 petroleum engineers were employed in 1976, mostly in the petroleum industry and closely allied fields. Their employers include not only the major oil companies, but also the hundreds of smaller independent oil exploration and production companies. They also work for companies that produce drilling equipment and supplies. Some petroleum engineers work in banks and other financial institutions which need their knowledge of the economic value of oil and gas properties. A small number work for engineering consulting firms or as independent consulting engineers, and for the Federal and State governments.

The petroleum engineer's work is concentrated in places where oil and gas are found. Almost three-fourths of all petroleum engineers are employed in the oil producing States of Texas, Oklahoma, Louisiana, and California. There are many American petroleum engineers working overseas in oil producing countries.

Employment Outlook

[illegible] expected to grow faster than the average for all occupations through the mid-1980's. Economic expansion will require increasing supplies of petroleum and natural gas [illegible] With [illegible] and high petroleum prices, increasingly sophisticated [illegible] recovery methods will be used. Also, new sources of oil [illegible] shale and [illegible] oil sources may be developed. All of these factors will contribute to increasing demand for petroleum engineers. (See introductory part of this section for information on [illegible] and earnings.)

Sources of Additional Information

[illegible]

Petroleum engineers discuss problem with drilling supervisor.

BROADCAST TECHNICIANS

[illegible]

88

[illegible]

[illegible] in the [illegible] used to record and transmit [illegible] television programs. They [illegible] with microphones, [illegible] light and sound effects, television cameras, video tape recorders, and other equipment.

In the control [illegible] technicians operate [illegible] and regulates the quality of sound and pictures being recorded or broadcast. They also operate controls that switch broadcasts from one camera [illegible] programming [illegible] network [illegible] programs. By means of [illegible] and intercom [illegible] telephone headsets, they give technical directions to personnel in the studio.

When events outside the studio are to be broadcast, technicians may go to the site and set up, test, and operate the equipment. After the broadcast, they dismantle the equipment and return it to the station.

As a rule, broadcast technicians in small stations perform a variety of duties. In large stations and in [illegible] work, on the other hand, technicians are more specialized, although specific job assignments may change from day to day. *Transmitter technicians* monitor and log outgoing signals and are responsible for transmitter operation. *Maintenance technicians* set up, maintain, and repair electronic broadcasting equipment. *Audio control technicians* regulate sound pickup, transmission, and switching, and *video control technicians* regulate the quality, brightness, and contrast of television pictures. The lighting of television programs is directed by *lighting technicians*. For programs originating outside the studio, *field technicians* set up and operate broadcasting equipment. *Recording technicians* operate and maintain sound recording equipment; *video recording technicians* operate and maintain video tape recording equipment. Sometimes the term "engineer" is substituted for "technician."

Places of Employment

About 22,000 broadcast technicians were employed in radio and television stations in 1976. Most radio stations employ fewer than four technicians, although a few large ones have more than 10. Nearly all television stations employ at least 10 broadcast technicians, and those in large metropolitan areas average about 30. In addition to these technicians, some supervisory personnel with job titles such as chief engineer or director of engineering work in engineering departments.

Although broadcast technicians are employed in every State, most are located in large metropolitan areas. The highest paying and most specialized jobs are concentrated in New York, Los Angeles, and Washington, D.C., the originating centers for most of the network programs.

Training, Other Qualifications, and Advancement

[illegible] broadcast technician should plan [illegible] First Class Radiotelephone Operator License from the Federal Communications Commission (FCC). Federal law requires that anyone who operates broadcast transmitters in television stations must hold such a license. The law also requires that the chief engineer of a broadcasting station hold a first class license. The FCC issues a Third Class Operator License, too, and some stations require all their broad-

Broadcast technician makes video tape recording on electronic equipment

cast technicians to have one or the other of these licenses. Applicants for an FCC license must pass a series of written examinations. These cover construction and operation of transmission and receiving equipment, characteristics of electromagnetic waves, and regulations and practices both Federal and International which govern broadcasting.

Among high school courses, algebra, trigonometry, physics, electronics, and other sciences provide valuable background for persons anticipating careers in this occupation. Building and operating an amateur radio station also is good training. Taking an electronics course in a technical school is still another good way to acquire the knowledge for becoming a broadcast technician. Some persons gain work experience as temporary employees while filling in for regular broadcast technicians who are on vacation.

Many schools give [illegible] specially designed to prepare the student for the FCC's first class license test. Technical school or college training is an advantage for those who hope to advance to supervisory positions or to the more specialized jobs in large stations and in the networks.

Persons with FCC first class licenses who get entry jobs are instructed and advised by the chief engineer or by other experienced technicians concerning the work procedures of the station. In small stations, they may start by operating the transmitter and handling other technical duties, after a brief instruction period. As they acquire more experience and skill they are assigned to more responsible jobs. Those who demonstrate above average ability may move into top level technical positions such as supervisory technician or chief engineer. A college degree in engineering is becoming increasingly important for advancement to supervisory and executive positions.

Employment Outlook

[illegible] technicians face [illegible], especially in major metropolitan areas where the number of qualified jobseekers exceeds the number of openings. Job prospects may be better in smaller cities for people with appropriate training in electronics.

Employment of broadcast technicians is expected to increase about as fast as the average for all occupations through the mid 1980's. Most job openings, however, will result from the need to replace experienced technicians who retire, die, or transfer to other occupations.

Some new job opportunities for technicians will arise as new radio and television stations go on the air. Demand for broadcast technicians also will increase as cable television stations broadcast more of their own programs. At the same time, technological developments are likely to limit future demand; such laborsaving technical advances as automatic programming, automatic operation logging, and remote control of transmitters all hold down demand for additional technicians.

Earnings and Working Conditions

Salaries of beginning technicians in commercial radio and television ranged from about $155 to $215 a week in 1976 and those of experienced technicians from about $200 to $450, according to the limited information available. As a rule, technicians' wages are highest in large cities and in large stations. Technicians employed by television stations usually are paid more than those who work for radio stations because television work is generally more complex. Technicians employed by educational broadcasting stations generally earn less than those who work for commercial stations.

Most technicians in large stations work a 40 hour week with overtime pay for additional hours. Some broadcast technicians in the larger cities work a 37 hour week. In small stations, many technicians work 4 to 12 hours of overtime each week. Evening, night, and weekend work frequently is necessary, since many stations are on the air as many as 24 hours a day, 7 days a week. Network technicians may occasionally have to work continuously for many hours and under great pressure in order to meet broadcast deadlines.

Technicians generally work indoors in pleasant surroundings. The work is interesting, and the duties are varied. When remote pickups are made, however, technicians may work out of doors at some distance from the studios, under less favorable conditions.

Sources of Additional Information

Information about radiotelephone operator's examinations, and guides to study for them, write to:

Federal Communications Commission, Washington, D.C. 20554

For information on careers for broadcast technicians, write to:

National Association of Broadcasters, 1771 N St. NW., Washington, D.C. 20036

Corporation for Public Broadcasting, 1111 16th St. NW., Washington, D.C. 20036

DRAFTERS

(D.O.T. 001.281, 002.281, 003.281, 005.281, 007.281, 010.281, 014.281, and 017.)

Nature of the Work

When building a space capsule, television set, or bridge, workers follow drawings that show the exact dimensions and specifications of the entire object and each of its parts. Workers who draw these plans are drafters.

Drafters prepare detailed drawings based on rough sketches, specifications, and calulations made by scientists, engineers, architects, and designers. They also calculate the strength, quality, quantity, and cost of materials. Final drawings contain a detailed view of the object from all sides as well as specifications for materials to be used, procedures followed, and other information to carry out the job.

In preparing drawings, drafters use compasses, dividers, protractors, triangles, and other drafting devices. They also use engineering handbooks, tables, and calculators to help solve technical problems.

Drafters are classified according to the work they do or their level of responsibility. *Senior drafters* translate an engineer's or architect's preliminary plans into design "layouts" (scale drawings of the object to be built). *Detailers* draw each part shown on the layout, and give dimensions, materials, and other information to make the drawing clear and complete. *Checkers* carefully examine drawings for errors in computing or recording dimensions and specifications. Under the supervision of experienced drafters, *tracers* make minor corrections and trace drawings for reproduction on paper or plastic film.

Drafters may specialize in mechanical, electrical, aeronautical, structural, or architectural drafting.

Drafters usually specialize in a particular field of work, such as mechanical, electrical, electronic, aeronautical, structural, or architectural drafting.

Places of Employment

About 320,000 persons worked as drafters in 1976; more than 9 out of 10 worked in private industry. Engineering and architectural firms employed about 3 out of the 10. Other major employers included the fabricated metals, electrical equipment, machinery, and construction industries.

About 20,000 drafters worked for Federal, State, and local governments in 1976. Most drafters in the Federal Government worked for the Defense Department; those in State and local governments were mainly in highway and public works departments. Another several thousand drafters worked for colleges and universities and nonprofit organizations.

Training, Other Qualifications, and Advancement

Persons interested in becoming drafters can acquire the necessary training in technical institutes, junior and community colleges, extension divisions of universities, and vocational and technical high schools. Some persons receive training and experience in the Armed Forces. Others qualify through on-the-job training programs combined with part-time schooling or 3- to 4-year apprenticeship programs.

Training for a career in drafting, whether in a high school or posthigh school program, should include courses in mathematics, physical sciences, mechanical drawing, and drafting. Shop practices and shop skills also are helpful since many higher level drafting jobs require knowledge of manufacturing or construction methods. Many technical schools offer courses in structural design, architectural drawing, and engineering or industrial technology.

Those planning careers in drafting should be able to do freehand drawings of three-dimensional objects and also detailed work requiring a high degree of accuracy. They should have good eyesight and manual dexterity. In addition, they should be able to function as part of a team since they work directly with engineers, architects, and skilled workers. Artistic ability is helpful in some specialized fields.

High school graduates usually start out as tracers. Those having posthigh school technical training may begin as junior drafters. After gaining experience, they may advance to checkers, detailers, senior drafters, or supervisors. Some may become independent designers. Courses in engineering and mathematics sometimes enable drafters to transfer to engineering positions.

Employment Outlook

Employment of drafters is expected to increase faster than the average for all occupations. This growth, along with the need to replace those who retire, die, or move into other fields of work, should provide favorable job opportunities through the mid-1980's. Holders of an associate (2-year) degree in drafting will have the best prospects. Many large employers already require postsecondary technical education, though well-qualified high school graduates who have studied drafting may find opportunities in some types of jobs.

Employment of drafters is expected to rise rapidly as a result of the increasingly complex design problems of modern products and processes. In addition, more support personnel will be needed as the employment of engineers and scientists grows. Photoreproduction of drawings and expanding use of electronic drafting equipment and computers, however, will reduce the need for less skilled drafters.

Earnings and Working Conditions

In [illegible] industry, [illegible] averaged about $8,400 a year in [illegible], while more experienced drafters averaged between $9,800 and $12,000 a year. Senior drafters averaged about $15,300 a year in 1976. On the average, experienced drafters earn about one and one-half times as much as the average earnings of nonsupervisory workers in private industry, except farming.

The Federal Government paid drafters having an associate degree starting salaries of $8,316 a year in 1977. Those with less education or experience generally started at $7,408. The average Federal Government salary for all drafters was about $11,000 a year.

Although drafters usually work in well-lighted and well-ventilated rooms, they often must sit for long periods of time doing very detailed work. Occasionally, drafters may visit other offices or construction sites to gain first-hand information about a certain assignment.

Sources of Additional Information

General information on careers for drafters is available from:

American Institute for Design and Drafting, 3119 Price Rd., Bartlesville, Okla. 74003.

International Federation of Professional and Technical Engineers, 1126 16th St. NW., Washington, D.C. 20036.

See Sources of Additional Information in the statement on engineering and science technicians elsewhere in the *Handbook*.

ENGINEERING AND SCIENCE TECHNICIANS

(D.O.T. 002. through 029.)

Nature of the Work

[illegible] knowledge of science, [illegible] industrial machinery, and technical processes enables engineering and science technicians to work in all phases of business and government, from research and design to manufacturing, sales, and customer service. Although their jobs are more limited in scope and more practically oriented than those of engineers or scientists, technicians often apply the theoretical knowledge developed by engineers and scientists to actual situations. Technicians frequently use complex electronic and mechanical instruments, experimental laboratory equipment, and drafting instruments. Almost all technicians described in this statement must be able to use technical handbooks and computing devices such as slide rules and calculating machines.

In research and development, one of the largest areas of employment, technicians set up experiments and calculate the results using complex instruments. They also assist engineers and scientists in developing experimental equipment and models by making drawings and sketches and, frequently, by doing routine design work.

In production, technicians usually follow the plans and general directions of engineers and scientists, but often without close supervision. They may prepare specifications for materials, devise tests to insure product quality, or study ways to improve the efficiency of an operation. They often supervise production workers to make sure they follow prescribed plans and procedures. As a product is built, technicians check to see that specifications are followed, keep engineers and scientists informed as to progress, and investigate production problems.

As sales workers or field representatives for manufacturers, technicians give advice on installation and maintenance of complex machinery, and may write specifications and technical manuals. (See statement on technical writers elsewhere in the *Handbook*.)

Technicians may work in the fields of engineering, physical science, or life science. Within these general fields, job titles may describe the level (biological aide or biological technician), duties (quality control technician or time study analyst), or area of work (mechanical, electrical, or chemical).

As an engineering technician, one might work in any of the following areas:

Aeronautical technology. Technicians in this area work with engineers and scientists to design and produce aircraft, rockets, guided missiles, and spacecraft. Many aid engineers in preparing design layouts and models of structures, control systems, or equipment installations by collecting information, making computations, and performing laboratory tests. For example, a technician might estimate weight factors, centers of gravity, and other items affecting load capacity of an airplane or missile. Other technicians prepare or check drawings for technical accuracy, practicability, and economy.

Aeronautical technicians frequently work as manufacturers' field service representatives, serving as the link between their company and the military services, commercial airlines, and other customers. Technicians also prepare technical information for instruction manuals, bulletins, catalogs, and other litera-

ture. (See statements on aerospace engineers, airplane mechanics, and occupations in aircraft, missile, and spacecraft manufacturing elsewhere in the *Handbook*.)

Air-Conditioning, Heating, and Refrigeration Technology. Air-conditioning, heating, and refrigeration technicians design, manufacture, sell, and service equipment to regulate interior temperatures. Technicians in this field often specialize in one area, such as refrigeration, and sometimes in a particular type of activity, such as research and development.

When working for firms that manufacture temperature-controlling equipment, technicians generally work in research and engineering departments, where they assist engineers and scientists in the design and testing of new equipment or production methods. For example, a technician may construct an experimental model to test its durability and operating characteristics. Technicians also work as sales workers for equipment manufacturers or dealers, and must be able to supply engineering firms and other contractors that design and install systems with information on installation, maintenance, operating costs, and the performance specifications of the equipment. Other technicians work for contractors, where they help design and prepare installation instructions for air conditioning, heating, or refrigeration systems. Still others work in customer service, and are responsible for supervising the installation and maintenance of equipment. (See statement on refrigeration and air-conditioning mechanics elsewhere in the *Handbook*.)

Civil Engineering Technology. Technicians in this area assist civil engineers in planning, designing, and constructing highways, bridges, dams, and other structures. They often specialize in one area such as highway or structural technology. During the planning stage, they estimate costs, prepare specifications for materials, or participate in surveying, drafting, or designing. Once construction begins, they assist the contractor or superintendent in scheduling construction activities or inspecting the work to assure conformance to blueprints and specifications. (See statements on civil engineers, drafters, and surveyors elsewhere in the *Handbook*.)

Electronics Technology. Technicians in this field develop, manufacture, and service electronic equipment and systems. The types of equipment range from radio, radar, sonar, and television to industrial and medical measuring or control devices, navigational equipment, and electronic computers. Because the field is so broad, technicians often specialize in one area such as automatic control devices or electronic amplifiers. Furthermore, technological advancement is constantly opening up new areas of work. For example, the development of printed circuits stimulated the growth of miniaturized electronic systems.

When working in design, production, or customer service, electronic technicians use sophisticated measuring and diagnostic devices to test, adjust, and repair equipment. In many cases, they must understand the requirements of the field in which the electronic device is being used. In designing equipment for space exploration, for example, they must consider the need for minimum weight and volume and maximum resistance to shock, extreme temperature, and pressure. Some electronics technicians also work in technical sales, while others work in the radio and television broadcasting industry. (See statements on broadcast technicians and occupations in radio and television broadcasting elsewhere in the *Handbook*.)

Industrial Production Technology. Technicians in this area, usually called industrial or production tech-

Since technicians are part of a scientific team, they sometimes work under the supervision of engineers and scientists.

nicians, assist industrial engineers on problems involving the efficient use of personnel, materials, and machines to produce goods and services. They prepare layouts of machinery and equipment, plan the flow of work, make statistical studies, and analyze production costs. Industrial technicians also conduct time and motion studies (analyze the time and movements a worker needs to accomplish a task) to improve the production methods and procedures in manufacturing plants.

Many industrial technicians acquire experience that enables them to qualify for other jobs. For example, those specializing in machinery and production methods may move into industrial safety. Others, in job analysis, may set job standards and interview, test, hire, and train personnel. Still others may move into production supervision. (See statements on personnel workers and industrial engineers elsewhere in the *Handbook*.)

Mechanical technology. [illegible] technology is a broad term that covers a large number of specialized fields including automotive technology, diesel technology, tool design, machine design, and production technology.

Technicians [illegible] design and development work by making freehand sketches and rough layouts of proposed machinery and other equipment and parts. This work requires knowledge of mechanical principles involving tolerance, stress, strain, friction, and vibration factors. Technicians also analyze the costs and practical value of designs.

In planning [illegible] tal machines and equipment for performance, durability, and efficiency, technicians record data, make computations, plot graphs, analyze results, and write reports. They sometimes recommend design changes to improve performance. Their job often requires skill in the use of complex instruments, test equipment, and gauges, as well as in the preparation and interpretation of drawings.

When a product is ready for production, technicians help prepare layouts and drawings of the assembly process and of parts to be manufactured. They frequently help estimate labor costs, equipment life, and plant space. Some mechanical technicians test and inspect machines and equipment in manufacturing departments or work with engineers to eliminate production problems. Others are technical sales workers.

Tool designers are among the better known specialists in mechanical engineering technology. Tool designers prepare sketches of the designs for cutting tools, jigs, dies, special fixtures, and other devices used in mass production. Frequently, they redesign existing tools to improve their efficiency. They also make or supervise others in making detailed drawings of tools and fixtures.

Machine drafting, with some designing, is another major area often grouped under mechanical technology and is described in the statement on drafters. (Also see statements on mechanical engineers, automobile mechanics, manufacturers' sales workers, and diesel mechanics elsewhere in the *Handbook*.)

[illegible] mated manufacturing and industrial processes, oceanographic and space exploration, weather forecasting, satellite communication systems, environmental protection, and medical research have helped to make instrumentation technology a fast growing field for technicians. They help develop and design complex measuring and control devices such as those in a spacecraft that sense and measure changes in heat or pressure, automatically record data, and make necessary adjustments. These technicians have extensive knowledge of physical sciences as well as electrical-electronic and mechanical engineering. (See statement on instrument workers elsewhere in the *Handbook*.)

Several areas of opportunity exist in the physical sciences.

Chemical technicians work with chemists and chemical engineers to develop, sell, and utilize chemical and related products and equipment.

Most chemical technicians do research and development testing or other laboratory work. They often set up and conduct tests on processes and products being developed or improved. For example, a technician may examine steel for carbon, phosphorus, and sulfur content or test a lubricating oil by subjecting it to changing temperatures. The technician measures reactions, analyzes the results of experiments, and records data that will be the basis for decisions and future research.

Chemical technicians in production generally put into commercial operation those products or processes developed in research laboratories. They assist in making the final design, installing equipment, and training and supervising operators on the production line. Technicians in quality control test materials, production processes, and final products to insure that they meet the manufacturer's specifications and quality standards. Many also work as technical sales personnel, selling chemicals or chemical products.

Many chemical technicians use computers and instruments, such as a dilatometer (which measures the expansion of a substance). Because the field of chemistry is so broad, chemical technicians frequently specialize in a particular industry such as food processing or pharmaceuticals. (See statements on chemists, chemical engineers, and occupations in the industrial chemical industry elsewhere in the *Handbook*.)

Meteorological technicians support meteorologists in the study of atmospheric conditions. Technicians calibrate instruments, observe, record, and report meteorological occurrences, and assist in research projects and the development of scientific instruments.

Geological technicians assist geologists in evaluating earth processes. Currently much research is being conducted in seismology, petroleum and mineral exploration, and ecology. These technicians install seismographic instruments, record measurements from these instruments, assist in field evaluation of earthquake damage and surface displacement, or assist geologists in earthquake prediction research. In petroleum and mineral exploration,

they help conduct tests and record sound wave data to determine the likelihood of successful drilling, or use radiation detection instruments and collect core samples to help geologists evaluate the economic possibilities of mining a given resource.

Hydrologic technicians gather data to help hydrologists predict river stages and water quality levels. They monitor instruments that measure water flow, water table levels, or water quality, and record and analyze the data obtained. (See statement on environmental scientists elsewhere in the *Handbook*.)

Technician positions in the life sciences generally are classified into two categories:

Agricultural technicians work with agricultural scientists in the areas of food production and processing. Plant technicians conduct tests and experiments to improve the yield and quality of crops, or to increase resistance to disease, insects, or other hazards. Technicians in soil science analyse the chemical and physical properties of various soils to help determine the best uses for these soils. Animal husbandry technicians work mainly with the breeding and nutrition of animals. Other agricultural technicians are employed in the food industry as food processing technicians. They work in quality control or in food science research, helping food scientists develop better and more efficient ways of processing food material for human consumption. (See statement on food scientists elsewhere in the *Handbook*.)

Biological technicians work primarily in laboratories where they perform tests and experiments under controlled conditions. Microbiological technicians study microscopic organisms and may be involved in immunology or parasitology research. Laboratory animal technicians study and report on the reaction of laboratory animals to certain physical and chemical stimuli. They also study and conduct research to help biologists develop cures that may be applied to human diseases. Biochemical technicians assist biochemists in the chemical analysis of biological substances (blood, other body fluids, foods, drugs). Most of their work involves conducting experiments and reporting their results to a biochemist. As a biological technician, one might also work primarily with insects, studying insect control, developing new insecticides, or determining how to use insects to control other insects or undesirable plants. (See statements on life scientists elsewhere in the *Handbook*.)

Technicians also specialize in fields such as metallurgical (metal), electrical, and optical technology. In the atomic energy field, technicians work with scientists and engineers on problems of radiation safety, inspection, and decontamination. (See statement on occupations in the atomic energy field elsewhere in the *Handbook*.) New areas of work include environmental protection, where technicians study the problems of air and water pollution, and industrial safety.

Places of Employment

Over 585,000 persons worked as engineering and science technicians in 1976. Almost 400,000 worked in engineering fields, about 130,000 in the physical science occupations, and about 55,000 in the life sciences.

About two-thirds of all technicians worked in private industry. In the manufacturing sector, the largest employers were the electrical equipment, chemical, machinery, and aerospace industries. In nonmanufacturing, large numbers worked in wholesale and retail trade, communications, and in engineering and architectural firms.

In 1976, the Federal Government employed about 95,000 technicians, chiefly as engineering and electronics technicians, equipment specialists, biological technicians, cartographic technicians (mapmaking), meteorological technicians, and physical science technicians. The largest number worked for the Department of Defense; most of the others worked for the Departments of Transportation, Agriculture, Interior, and Commerce.

State government agencies employed nearly 50,000 engineering and science technicians, and local governments about 11,500. The remainder worked for colleges and universities and nonprofit organizations.

Training, Other Qualifications, and Advancement

Although persons can qualify for technician jobs through many combinations of work experience and education, most employers prefer applicants who have had some specialized technical training. Specialized training is available at technical institutes, junior and community colleges, area vocational-technical schools, extension divisions of colleges and universities, and vocational-technical high schools. Some engineering and science students who have not completed the bachelor's degree and others who have degrees in science and mathematics also are able to qualify for technician positions.

Persons also can qualify for technician jobs by less formal methods. Workers may learn through on-the-job training, apprenticeship programs, or correspondence schools. Some qualify on the basis of experience gained in the Armed Forces. However, postsecondary training is becoming increasingly necessary for advancement to more responsible jobs.

Some of the types of postsecondary and other schools that provide technical training are discussed in the following paragraphs:

Technical Institutes. Technical institutes offer training to qualify students for a job immediately after graduation with a minimum of on-the-job training. In general, students receive intensive technical training but less theory and general education than in engineering schools or liberal arts colleges. A few technical institutes and community colleges offer cooperative programs in which students spend part of the time in school and part in paid employment related to their studies.

Some technical institutes operate as regular or extension divisions of colleges and universities. Other institutions are operated by States and municipalities, or by private organizations.

Junior and Community Colleges. Curriculums in junior and community colleges which prepare students

for technician occupations are similar to those in technical institutes, but with more emphasis on theory and liberal arts course work. After completing the 2-year programs, some graduates qualify for technician jobs while others continue their education at 4-year colleges. Most large community colleges offer 2-year technical programs, and many employers prefer graduates who have more specialized training.

Area Vocational-Technical Schools. These postsecondary public institutions serve students from surrounding areas and train them for jobs in the local area. Most of these schools require a high school degree or its equivalent for admission.

Other Training. Some large corporations conduct training programs and operate private schools to meet their needs for technically trained personnel in specific jobs, such training rarely includes general studies. Training for some technician occupations, for instance tool designers and electronic technicians, is available through formal 2- to 4 year apprenticeship programs. The apprentice gets on-the-job training under the close supervision of an experienced technician and related technical knowledge in classes, usually after working hours.

The Armed Forces have trained many technicians, especially in electronics. Although military job requirements generally are different from those in the civilian economy, military technicians often are able to find employment with only minimal additional training.

Technician training also is available from many private technical and correspondence schools that often specialize in a single field such as electronics. Some of these schools are owned and operated by large corporations that have the resources to provide very up-to-date training in a technical field.

Those interested in a career as a technician should have an aptitude for mathematics and science and enjoy technical work. An ability to do detailed work with a high degree of accuracy is necessary; for design work, creative talent also is desirable. Since technicians are part of a scientific team, they sometimes must work under the close supervision of engineers and scientists as well as with other technicians and skilled workers. Some technicans, such as repair and maintenance technicians, should be able to deal effectively with customers requiring their services.

Engineering and science technicians usually begin work as trainees in routine positions under the direct supervision of an experienced technician, scientist, or engineer. As they gain experience, they receive more responsibility and carry out a particular assignment under only general supervision. Technicians may eventually move into supervisory positions. Those who have the ability and obtain additional education sometimes are promoted to positions as scientists or engineers.

Employment Outlook

Employment opportunities for engineering and science technicians are expected to be favorable through the mid-1980's. Opportunities will be best for graduates of postsecondary school technician training programs. Besides the openings resulting from the faster-than average growth expected in this field, additional technicians will be needed to replace those who die, retire, or leave the occupation.

Industrial expansion and the increasing complexity of modern technology underlie the anticipated increase in demand for technicians. Many will be needed to work with the growing number of engineers and scientists in developing, producing, and distributing new and technically advanced products. Automation of industrial processes and growth of new areas of work such as environmental protection and urban development will add to the demand for technical personnel.

The anticipated growth of research and development expenditures in industry and government should increase requirements for technicians.

Because space and defense programs are major factors in the employment of technical personnel, expenditures in these areas affect the demand for technicians. The outlook for technicians is based on the assumption that defense spending will increase from the 1976 level by the mid-1980's, but will still be slightly lower than the levels of the late 1960's. If defense spending should differ substantially from this level, the demand for technicians would be affected accordingly.

Earnings

In private industry in 1976, average starting salaries for 2-year graduates ranged from about $9,000 to $10,800 a year, while those who did not complete a 2-year program earned average starting salaries from just over $6,400 to about $9,300. Senior engineering technicians in private industry earned average salaries of about $16,000 a year.

Starting salaries for all technicians in the Federal Government were fairly uniform in 1977. A high school graduate with no experience could expect $6,572 annually to start. With an associate degree, the starting salary was $8,316, and with a bachelor's, $9,303 or $11,523. At higher experience levels, however, differences in earnings are significant. The average annual salary for all engineering technicians employed by the Federal Government in 1977 was $17,800; for physical science technicians, $17,100; and for life science technicians, about $11,400.

Sources of Additional Information

Information on careers for engineering and science technicians and engineering and technology programs, contact:

Engineers Council for Professional Development, 345 East 47th St., New York, N.Y. 10017

Information on schools offering technician programs is available from:

National Association of Trade and Technical Schools, Accrediting Commission, 2021 L St. NW., Washington, D.C. 20036.

U.S. Department of Health, Education, and Welfare, Office of Education, Washington, D.C. 20202.

State departments of education also have information about approved technical institutes, junior colleges, and other educational insti-

tutions within the State offering post-high school training for specific technical occupations. Other sources include:

American Association of Community and Junior Colleges, Suite 410, 1 Dupont Circle, Washington, D.C. 20036.

National Home Study Council, 1601 18th St. NW., Washington, D.C. 20009.

SURVEYORS

(D.O.T. 018.188)

Nature of the Work

Before engineers can plan highways or other construction projects, they need complete and accurate information about boundaries, land features, and other characteristics of the construction site. Surveyors measure construction sites, help establish official land boundaries, assist in setting land valuations, and collect information for maps and charts.

Surveyors often work as party chiefs; that is, they are in charge of a field party that determines the precise measurements and locations of elevations, points, lines, and contours on the earth's surface, and distances between points. Surveyors are directly responsible for the field party's activity and the accuracy of its work. They plan the field work, select survey reference points, and determine the precise location of natural and manmade features of the survey region. They record the information disclosed by the survey, verify the accuracy of the survey data, and prepare sketches, maps, and reports.

A typical field party is made up of the party chief and three to six assistants and helpers. *Instrument workers* (D.O.T. 018.188) adjust and operate surveying instruments such as the theodolite (used to measure altitude). These workers also compile notes, sketches, and records of the data obtained from using these instruments. *Chain workers* (D.O.T. 018.687) use a steel tape or surveyor's chain to measure distances between surveying points. Generally chain workers operate in pairs, one holding the tape at the last established point, and the other marking an advanced measuring point. Chain workers also may mark measured points with painted stakes. *Rod workers* (D.O.T. 018.587) use a level rod, range pole, or other equipment to assist instrument workers in determining elevations, distances, and directions. They hold and move the range pole according to hand or verbal signals of the instrument worker to help establish the exact point of measurement. Rod workers also may clear brush from the survey line.

Surveyors often specialize in a particular type of survey. Besides doing *highway surveys*, many perform *land surveys* to locate boundaries of a particular tract of land. They then prepare maps and legal descriptions for deeds, leases, and other documents. Surveyors doing *topographic surveys* determine elevations, depressions, and contours of an area, and indicate the location of distinguishing surface features such as farms, buildings, forests, roads, and rivers. Other specialties include mining, pipeline, gravity, and magnetic surveying.

Several closely related occupations are geodesy and photogrammetry. Geodesists measure immense areas of land, sea, or space by taking into account the earth's curvature and its geophysical characteristics. (See statement on geophysicists elsewhere in the *Handbook*.) Photogrammetrists measure and interpret photographic images to determine the various physical characteristics of natural or manmade features of an area. By applying analytical processes and mathematical techniques to photographs obtained from aerial, space, ground, and underwater locations, photogrammetrists are able to make detailed maps of areas that are inaccessible or difficult to survey by other methods. Control surveys on the ground are made to determine the accuracy of maps derived from photogrammatic techniques.

Surveyors doing topographic surveys to determine elevations, depressions, and contours of an area.

Places of Employment

About 52,000 persons worked as surveyors in 1976. Federal, State, and local government agencies employ about 3 out of every 10 surveyors. Among the Federal Government agencies employing these workers are the U.S. Geological Survey, the Bureau of Land Management, the Army Corps of Engineers, and the Forest Service. Most surveyors in State and local government agencies work for highway departments and urban planning and redevelopment agencies.

A large number of surveyors work for construction companies and for engineering and architectural consulting firms. A sizable number either work for or own firms that conduct surveys for a fee. Significant numbers of surveyors also work for crude petroleum and natural gas companies, and for public utilities.

Training, Other Qualifications, and Advancement

Most persons prepare for surveying work by combining postsecondary school courses in surveying and extensive on-the-job training. Some prepare by obtaining a college degree. Junior and community colleges, technical institutes, and vocational schools offer 1-, 2-, and 3-year programs in surveying. A few 4-year colleges offer bachelor's degrees specifically in surveying, while many others offer several courses in the field.

High school students interested in pursuing a career in surveying should take courses in algebra, geometry,

trigonometry, drafting, and mechanical drawing.

High school graduates with no formal training in surveying usually start as rod workers. After several years of on-the-job experience and some formal training in surveying, it is possible to advance to chain worker, instrument worker, and finally to party chief.

Beginners with postsecondary school training in surveying can generally start as instrument workers. After gaining experience, they usually advance to party chief, and may later seek to become a registered surveyor. In many instances, promotions to higher level positions are based on written examinations as well as experience.

For those interested in a career as a photogrammetrist, a bachelor's degree in engineering or the physical sciences is usually needed. Most photogrammetry technicians have had some specialized postsecondary school training.

All 50 States require licensing or registration of land surveyors responsible for locating and describing land boundaries. Registration requirements are generally quite strict because once registered, surveyors can be held legally responsible for their work. Requirements for licensure vary among the States but in general they include a combination of 3 to 8 years' experience in surveying and passing an examination. A few States now require a bachelor's degree emphasizing surveying, as a prerequisite to licensure.

In 1976, about 23,000 land surveyors were registered. In addition about 13,500 engineers were registered to do land surveying, primarily as part of their civil engineering duties; however, these workers are considered engineers rather than surveyors. (See statement on civil engineers elsewhere in the *Handbook*.)

Surveyors should have the ability to visualize and understand objects, distances, sizes, and other abstract forms. Also, because surveying mistakes can be very costly, surveyors must perform mathematical calculations quickly and accurately while paying close attention to the smallest detail. Leadership qualities also are important as surveyors must supervise the work of others.

Members of a survey party must be in good physical condition in order to work outdoors and carry equipment over difficult terrain. They also need good eyesight, coordination, and hearing in order to communicate over great distances by hand signals or voice calls.

Employment Outlook

Employment of surveyors is expected to grow faster than the average for all occupations through the mid 1980's. In addition to the openings resulting from growth, many will result from the need to replace those who die, retire, or transfer to other fields of work.

The rapid development of urban areas and increased land values should create jobs for surveyors to locate boundaries for property records. Others will be needed to lay out streets, shopping centers, housing developments, and recreation areas. Construction and improvement of the Nation's roads and highways also will require many new surveyors. However, periods of slow construction activity could limit the demand for surveyors at those particular times.

Continuing expansion of technician and technology programs in postsecondary schools will create a need for more surveying teachers.

Earnings and Working Conditions

[illegible] the Federal Government [illegible] high school graduates with no [illegible] no training or experience started as rod workers or chain workers with an annual salary of $6,572. Those with 1 year of related postsecondary training earned $7,408. Those with an associate degree that included courses in surveying generally started as instrument workers with an annual salary of $8,316. The majority of surveyors who worked as party chiefs in the Federal Government earned between $10,000 and $14,000 per year and some high-level positions earned more than $17,000 per year.

Although salaries in private industry vary by geographic area, limited data indicate that salaries are generally comparable to those in Federal service and are above the average earnings of nonsupervisory workers in private industry, except farming.

Surveyors usually work an 8-hour, 5-day week. However, they sometimes work longer hours during the summer months when weather conditions are most suitable for surveying. The work of surveyors is active and sometimes strenuous. They often stand for long periods and walk long distances or climb hills with heavy packs of instruments and equipment. Because most work is out-of-doors, surveyors are exposed to all types of weather. Some duties, such as planning surveys, preparing reports and computations, and drawing maps, usually are done in an office.

Sources of Additional Information

Information about training and career opportunities in surveying is available from:

American Congress on Surveying and Mapping, 210 Little Falls St., Falls Church, Va. 22046.

General information on careers in photogrammetry is available from:

American Society of Photogrammetry, 105 North Virginia Ave., Falls Church, Va. 22046.

What to Look For in this Reprint

To make the *Occupational Outlook Handbook* easier to use, each occupation or industry follows the same outline. Separate sections describe basic elements, such as work on the job, education and training needed, and salaries or wages. Some sections will be more useful if you know how to interpret the information as explained below.

The TRAINING, OTHER QUALIFICATIONS, AND ADVANCEMENT section indicates the preferred way to enter each occupation and alternative ways to obtain training. Read this section carefully because early planning makes many fields easier to enter. Also, the level at which you enter and the speed with which you advance often depend on your training. If you are a student, you may want to consider taking those courses thought useful for the occupations which interest you.

Besides training, you may need a State license or certificate. The training section indicates which occupations generally require these. Check requirements in the State where you plan to work because State regulations vary.

Whether an occupation suits your personality is another important area to explore. For some you may have to make responsible decisions in a highly competitive atmosphere. For others, you may do only routine tasks under close supervision. To work successfully in a particular job, you may have to do one or more of the following:

- motivate others
- direct and supervise others
- work with all types of people
- work with things — you need [illegible] and manual dexterity
- work independently — you need [illegible] self discipline
- work as part of a team
- work with details [illegible] or laboratory reports
- help people
- use creative [illegible]
- work in a confined [illegible]
- do physically hard [illegible]
- work outside in all types of [illegible]

[illegible] and abilities so you can judge whether [illegible] istics suit you.

The EMP[illegible] the job market is likely to be favorable. Usually [illegible] expected growth is compared to the average projected growth rate for all occupations (20.1 percent between 1976 and 1985). The following phrases are used:

Much faster	
Faster	25.0 [illegible]
About as fa[illegible]	15.0 to 24.9%
Slower	4.0 to 14.9%
Little change	3.9 to 3.9%
Decline	4.0% or more

Generally, job op[illegible] growing at least as fast as the economy as a [illegible]

But, you would have to know the number of people [illegible] peting with you to be sure of your prospects. Unfortunately, this supply information is lacking for most occupations.

There are exceptions, however, especially among professional occupations. Nearly everyone who earns a medical degree, for example, becomes a practicing physician. When the number of people pursuing relevant types of education and training and then entering the field can be compared with the demand, the outlook section indicates the supply/demand relationship as follows:

Excellent	Demand much greater than supply
Very good	Demand greater than supply
Good or favorable	Rough balance between demand and supply
May face competition	Likelihood of more supply than demand
Keen competition	Supply greater than demand

Competition or few job openings should not stop your pursuing a career that matches your aptitudes and interests. Even small or overcrowded occupations provide some jobs. So do those in which employment is growing very slowly or declining.

Growth in an occupation is not the only source of job openings because the number of openings from turnover can be substantial in large occupations. In fact, replacement needs are expected to create 70 percent of all openings between 1976 and 1985.

Finally, job prospects in your area may differ from those in the Nation as a whole. Your State employment service can furnish local information.

The EARNINGS section tells what workers were earning in 1976.

Which jobs pay the most is a hard question to answer because good information is available for only one type of earnings — wages and salaries — and not even this for all occupations. Although 9 out of 10 workers receive this form of income, many earn extra money by working overtime, night shifts, or irregular schedules. In some occupations, workers also receive tips or commissions based on sales or service. Some factory workers are paid a piece rate — an extra payment for each item they make.

The remaining 10 percent of all workers — the self-employed — includes people in many occupations — physicians, barbers, writers, and farmers, for example. Earnings for self-employed workers even in the same occupation differ widely because much depends on whether one is just starting out or has an established business.

Most wage and salary workers receive fringe benefits, such as paid vacations, holidays, and sick leave.

Workers also receive income in goods and services (payment in kind). Sales workers in department stores, for example, often receive discounts on merchandise.

Despite difficulties in determining exactly what people earn on the job, the Earnings section does compare occupational earnings by indicating whether a certain job pays more or less than the average for all nonsupervisors in private industry, excluding farming.

Each occupation has many pay levels. Beginners almost always earn less than workers who have been on the job for some time. Earnings also vary by geographic location but cities that offer the highest earnings often are those where living costs are most expensive.